REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 074-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing this collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503

1. AGENCY USE ONLY (Leave blank)

2. REPORT DATE
February 1990

3. REPORT TYPE AND DATES COVERED
Magazine

4. TITLE AND SUBTITLE
Gateway: Volume I Number 2

5. FUNDING NUMBERS
SPO900-94-D-0001

6. AUTHOR(S)
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8. PERFORMING ORGANIZATION REPORT NUMBER
GWI2

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Defense Technical Information Cntr.
DTIC/AI
Cameron Station
Alexandria, VA 22304-6145

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.
Free to public by contacting the Human Systems IAC.

12b. DISTRIBUTION CODE
A

13. ABSTRACT ***(Maximum 200 Words)***

This issue contains articles on the following subjects:1.Integrating Ergonomics Into System Design; 2.Ergonomics Databases; 3.MANPRINT: Remembering the Soldier; 4.NATO AGARD Test Battery and Perfomance Database

DTIC QUALITY INSPECTED 4

20010125 108

14. SUBJECT TERMS
System Design Antropemetrics MANPRINT Weapon Systems
Performance Assessment Human Factors

15. NUMBER OF PAGES
12

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UNLIMITED

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

VOLUME 1: NUMBER 2, SPRING 1990

CSERIAC GATEWAY

PUBLISHED BY THE CREW SYSTEM ERGONOMICS INFORMATION ANALYSIS CENTER

In this issue:

CSERIAC is a U.S. Department of Defense information analysis center operated by the University of Dayton Research Institute and hosted by the Harry G. Armstrong Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, Ohio.

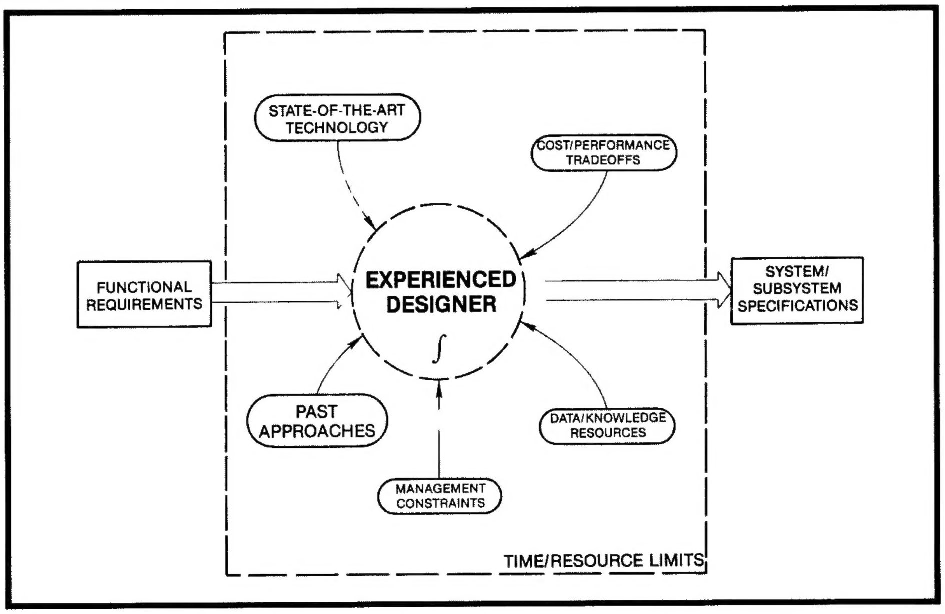

Figure 1. Simplified characterization of the design decision process.

INTEGRATING ERGONOMICS INTO SYSTEM DESIGN

DISTRIBUTION STATEMENT A
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Kenneth R. Boff

Despite spectacular advances in control, display, and information-handling technologies, the effectiveness of military systems is still inextricably linked to the performance of their human operators and maintainers. Failure to adequately consider human capabilities and limitations during the design process is a primary cause of operational deficiencies in military systems and equipment.

Recognizing this problem, the Department of Defense (DoD) has attempted to integrate ergonomics into the mainstream of system acquisition, design, and engineering to better match system specifications to operator characteristics.

At the forefront of these efforts is the Army's MANPRINT (Manpower and Personnel Integration) program, a comprehensive management and technical initiative to incorporate manpower, personnel, training, and other ergonomics requirements into the materiel acquisition process. [MANPRINT is described in detail on page 5 of this issue.] Similar programs have recently been inaugurated in the Air Force (IMPACTS, or Integrated Manpower, Personnel, and Comprehensive Training/Safety program) and in the Navy (HARDMAN, or Hardware vs. Manpower program).

Any effort to integrate ergonomics knowledge and resources into design decision making must take account of past failures of ergonomics to be naturally assimilated by the design process and design practitioners. System designers must be motivated to

Ergonomics, on page 2

Ergonomics, from page 1
seek and use ergonomics information. This requires an understanding of the "ergonomics of design," that is: (a) the nature of design decision making and the context in which it occurs; (b) the nature of designers in terms of their basic skills, inclinations, and limitations as architects of design decisions; and (c) the nature of potential design information and the way it is used and valued in the design process. Collectively, these factors determine how effectively ergonomics resources will be integrated into design decisions.

Nature of Design Decision Making

The general goal of system design is to conceive a system whose form and function fulfill defined needs and requirements within prescribed cost, schedule, and material constraints. The process of design decision making in pursuit of this goal (shown schematically in Fig. 1) is best represented as a subjective integration of information and experience, limited by available time and resources. It is an iterative process, recurring throughout all stages of design, and may involve different individuals or groups in the role of designer at different times.

The pressures of tight schedules and limited resources typical in system design drive designers to bias decisions and tradeoffs toward reducing uncertainty and risk. As a result, few new designs for complex systems represent original solutions, which may depend on untested approaches or new technology. Rather, most new designs are adaptations or variants of existing designs.

This strong dependence on prior designs as baselines makes it unlikely that designers will seek additional information beyond that viewed as sufficient to meet requirements. In other words, if ergonomics considerations are not embedded in the baseline design, such information is unlikely to be invoked unless it is specifically required and paid for. The scarcity of existing system baselines with a solid ergonomics foundation represents an obstacle to integrating ergonomics information into new systems.

Design effectiveness depends on the information factored into design decisions. Decisions made without considering potentially leveraging information may not be optimal and collectively may undermine system functioning.

One way to improve design effectiveness is to make ergonomics information more accessible to designers so it can be incorporated into design decision making more efficiently. Ironic as it seems, however, this task is hampered by the fact that designers are already deluged by too much potentially relevant information competing for their time and attention. If ergonomics information is to be considered adequately in design, a strategy is needed to make ergonomics data more competitive with other technical information in capturing the attention of designers.

The Nature of Designers

Who is the Designer? The design of complex military systems typically involves a large number of individuals, usually from many different organizations, who make decisions that determine the form and functionality of a given design. Though one might expect designers to constitute an easily recognizable, titled group of professionals, design decision making in system acquisition typically involves many individuals who identify with neither the role nor the responsibilities of the designer. This makes it difficult to maintain accountability for an evolving design and to support the design process.

A necessary first step in any strategy for influencing the design process is to identify the key participants in system acquisition and design. These individuals must be educated regarding their roles and responsibilities and must be held accountable for the consequences of their decisions on system effectiveness.

Designer Bias and Inclinations. A significant obstacle to institutionalizing the use of ergonomics information in system acquisition and design is the negative attitude of many engineers and managers toward ergonomics. The perception of many designers and managers is that the *costs* of integrating ergonomics considerations are too high, the *usefulness* of ergonomics design resources is too low, and the probable *gains* are insignificant.

As David Meister has pointed out, it is a common misconception among designers that humans are flexible enough to overcome design inefficiencies. Special attention to ergonomics considerations is therefore deemed unnecessary. Besides, it is argued, "good" engineers already take adequate account of the operator in system design.

If human performance data are to receive equal consideration with other technical information during design, then design decision makers must be persuaded or motivated to overcome ingrained biases against ergonomics.

Cost/Value Considerations in Information Use

In the design process, information is sought and used on the basis of its anticipated utility in making decisions, fulfilling requirements, or meeting system goals. Given the serious constraints of time and resources typically associated with the design of complex military systems, decision making is, by necessity, biased towards minimizing costs and maximizing benefits.

The benefits and costs associated with a design decision are linked to the *usefulness* and *usability* of the information factored into it. Information is "useful" to a given decision if it confers some advantage or benefit. The use of information may also exact costs, in terms of the time and

effort required to find, interpret, and apply the information in a given situation. Information is "usable" when these costs are low.

Figure 2 illustrates the underlying benefit-to-cost relationship between the usefulness and usability of technical information. Information should have optimal value or worth when both its usefulness and its usability are high (i.e., the benefits of use are great and the costs of use are low).

In the absence of objective measures of value, information is likely to be sought and used based on designers' expectations of its usefulness and usability in a given context. Given the negative bias of many designers and their organizational managers toward ergonomics specifications, the *perceived* value or worth of ergonomics information may at times be lower than its potential value.

Often, this is due to its poor usability. Although the research literature in human perception and performance contains much design-relevant data, the volume and diversity of the available information and the difficulty of interpreting scientific jargon make it hard for designers to find and utilize this information in addressing specific design problems. Thus, the high costs and risks of using such information can outweigh its potential benefits or usefulness in designers' eyes.

Mandating the use of ergonomics information in system design has been viewed as one means of ensuring that information of value is not ignored. However, success in regulating the use of information not generally *perceived* as valuable will ultimately depend on the consequences of nonuse, the likelihood that nonuse will be discovered (i.e., policing and inspection), and the anticipated costs associated with using the information (i.e., its usability).

This cost-benefit perspective on the value of information brings into focus the most critical challenge to institutionalizing the use of ergonomics resources in system design: namely,

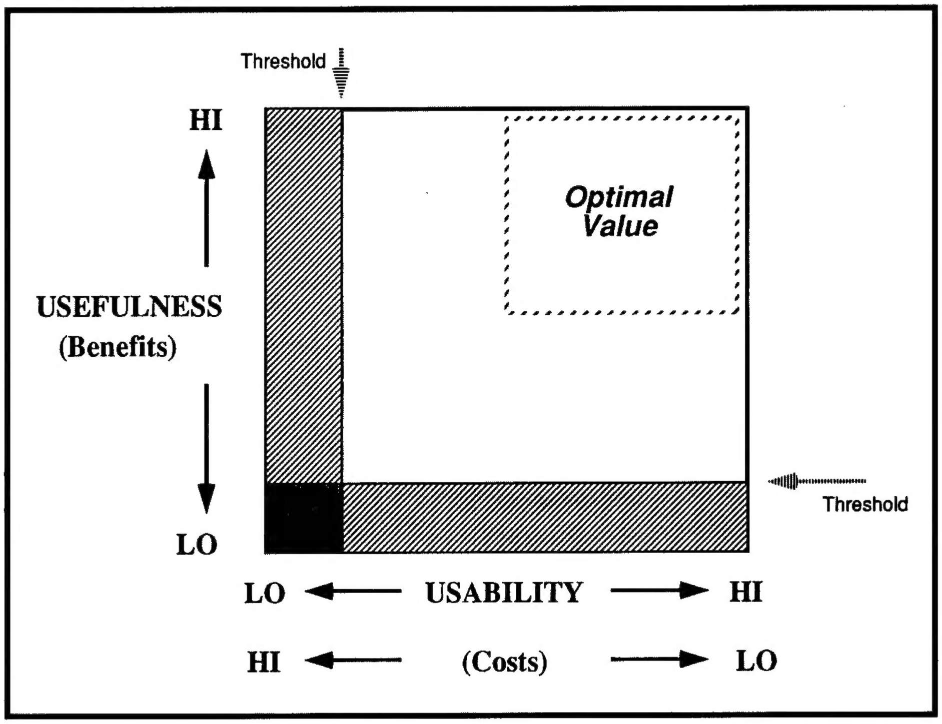


Figure 2. Relation between the usefulness and usability of technical information. Shaded arrows show the minimum acceptable levels below which information will not be used; dotted box indicates the region in which information is likely to have greatest value.

these resources must be positively valued by design decision makers, and their contribution to achieving system objectives must be fully recognized.

To raise the perceived value of ergonomics information among designers and stimulate the use of this information in the design process, steps must be taken to (1) increase the usability of ergonomics resources by reducing the costs and risks associated with their use; (2) educate design decision makers regarding the applicability of ergonomics resources and the benefits of their use; and (3) ensure that nonuse carries predictable and measurable consequences, for example, by introducing significant penalties for failure to comply with directives, regulations, and standards.

Conclusion

The design of effective military systems and equipment demands an integrated approach to system development in which the role of the human in training, operations, and maintenance is considered interdependent with the design of system hardware and software. It is the thesis here that enhancing human-system integration in the design of complex systems is itself an ergonomics design problem.

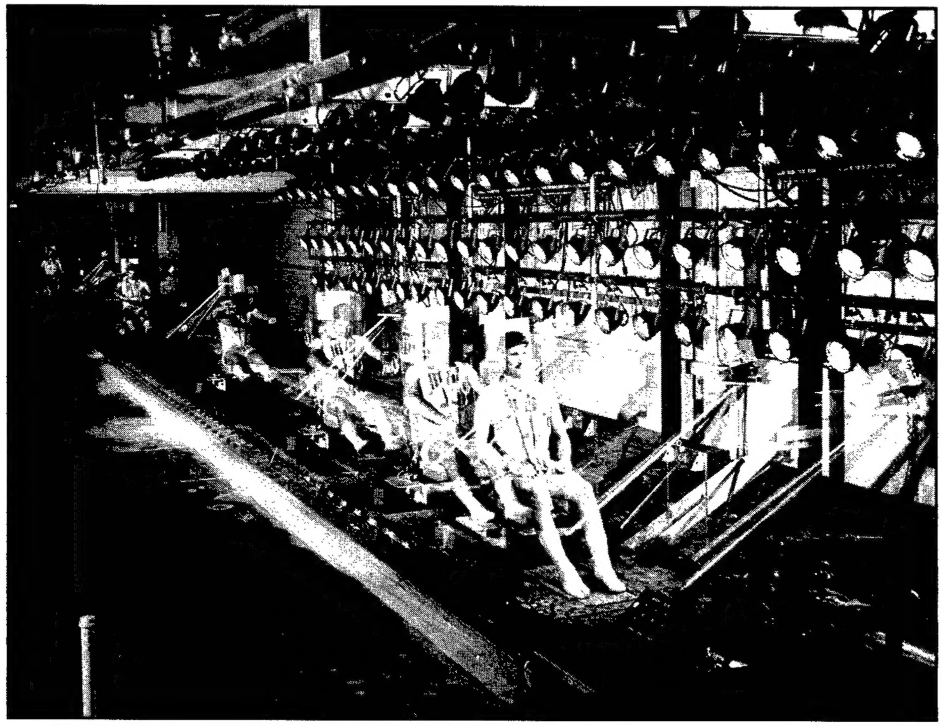
Success in achieving this goal can come only through understanding the process by which design decisions are made, the people who make these decisions, and the way technical information is valued and used in the design process. ●

Kenneth R. Boff is Director of Design Technology at the Human Engineering Division of the Harry G. Armstrong Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, OH.

This article is adapted from "Meeting the Challenge: Factors in the Design and Acquisition of Human-Engineered Systems," in H. R. Booher (Ed.), MANPRINT: An Approach to Systems Integration *(Van Nostrand Reinhold, Spring 1990) and is reprinted with permission of the publisher.*

TECHNOLOGY TRANSFER

Ergonomics Databases



An important part of CSERIAC's mission is to manage the transfer of crew system ergonomics technical products from developers to potential users for their mutual benefit. CSERIAC can currently provide access to two ergonomics databases: the Center for Anthropometric Research Data (CARD) Anthropometric Data Base and the Biodynamics Data Bank (BDB).

Center for Anthropometric Research Data (CARD) Anthropometric Data Base

The CARD Anthropometric Data Base is operated by the Armstrong Aerospace Medical Research Laboratory (AAMRL), Workload and Ergonomics Branch, at Wright-Patterson Air Force Base (WPAFB), Ohio. An online database developed to support human engineering design activities, the CARD database contains several hundred measurements of the human body across large population samples. Users can access anthropometric data from published surveys conducted worldwide.

For example, data are available from a survey of 1,905 USAF women conducted in the spring of 1968 by the Anthropology Branch of the Aerospace Medical Research Laboratory (WPAFB), and the Anthropology Research Project (Yellow Springs, Ohio). Data for this sample include age, 123 body size measurements, and grip strength.

A relational database system is used to manage the survey data and accommodate user queries. Access to the database is through a menu-driven applications software package. Available information includes measurement frequency data and summary statistics (mean, standard deviation, etc.), measurement descriptions, and measurement classification by body region and measurement type. A glossary of anthropometric terms and abstracts of the various anthropometric surveys are also available. New surveys are integrated into the database as they are received by the Center for Anthropometric Research Data.

Anyone needing anthropometric data may obtain direct access to the CARD database.

AAMRL Biodynamics Data Bank (BDB)

The Biodynamics Data Bank, sponsored by AAMRL, Modeling and Analysis Branch, WPAFB, is a repository for data from impact acceleration biodynamics experiments conducted by the Biomechanical Protection Branch of AAMRL (WPAFB). It is a general scientific data bank with a generic structure designed to fit the results of any scientific experiment, particularly those in the biosciences.

The BDB can hold complete raw (digital) data for smaller-scale biodynamics experiments. For large-scale experiments, it provides full indexing and offers extensive descriptive and summary data of each experimental test. For users who need more detailed results, the BDB also provides information on points of contact to obtain complete raw test data for each experiment.

The bibliographic records of the BDB include literature pertaining to biomechanics and related physiology as well as reports of research conducted at AAMRL and other laboratories, such as Department of Transportation research facilities.

Some uses of the BDB are:

- to quickly identify the objectives, scope, date, results, associated technical literature, etc., for a given study;
- to locate a set of tests with specific input or output parameters;
- to retrieve in-depth anthropometric data for all human subjects of the biodynamics experiments;
- to obtain experimental data for impact protection development, test facility development, etc.

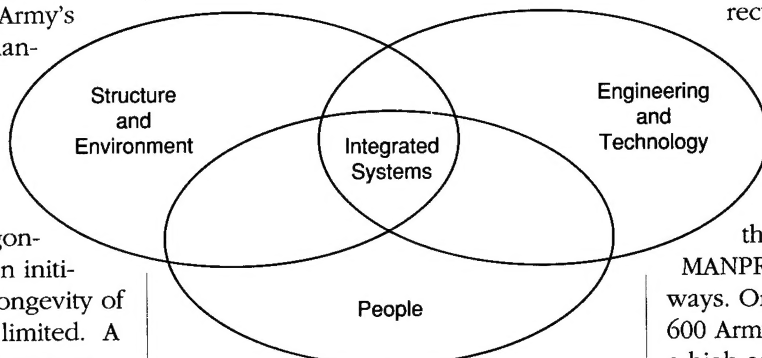
The data in the BDB are available through CSERIAC for use by the biodynamics research community.

For further information on either the CARD Anthropometric Data Base or the Biodynamics Data Bank, contact the CSERIAC Program Office. ●

MANPRINT: Remembering the Soldier

Barbara K. Frank

The United States Army's Manpower and Personnel Integration (MANPRINT) program was established to emphasize the human element in the design and acquisition of new weapon systems and equipment. In the past, the tendency was to focus attention on a weapon's technical capabilities; as a result, the design of some systems made them difficult for the average soldier to use. The Army's leadership realized that manpower, personnel, and training were not receiving adequate consideration in the acquisition process.



Government-related ergonomics programs have been initiated in the past, but the longevity of these programs has been limited. A large part of MANPRINT's success can be attributed to the support of top Army leadership. In 1984, General Maxwell Thurman, who was Vice Chief of Staff of the Army, issued the instructions that started the MANPRINT program. His interest in and support of the program were vital to changing the Army's materiel acquisition philosophy.

MANPRINT emphasizes six areas or domains: manpower, personnel, training, human factors engineering, health hazard, and system safety. Because these domains are oriented around the soldier, it was decided that the MANPRINT program would be managed by the Deputy Chief of Staff for Personnel at Department of the Army Headquarters.

MANPRINT's primary goal is to equip the man, not man the equipment. To accomplish this, all the domains receive careful analysis at each stage of the acquisition process. The MANPRINT domains must be consciously considered from the initial identification of a battlefield or training deficiency through the receipt of the new equipment at the unit level. An item of equipment cannot progress to the next phase of development until problematic MANPRINT issues are resolved.

This is not to say that all MANPRINT concerns must be eliminated; rather, decision makers are provided with information that permits intelligent tradeoffs to be made. This enables the Army to select the option that will result in improved warfighting capability.

The April 1987 publication of Army Regulation 602-2, Manpower and Personnel Integration (MANPRINT) in Materiel Acquisition, was key to institutionalizing the MANPRINT program. This regulation establishes MANPRINT policy and provides MANPRINT practitioners with detailed guidance on program implementation.

Department of Defense Directive 5000.53, Manpower, Personnel, Training and Safety (MPTS) in the Defense System Acquisition Process, serves this same purpose on a wider scale and implements MPTS throughout the Department of Defense. The Air Force and Navy have initiated programs similar to MANPRINT (IMPACTS, or Integrated Manpower, Personnel, and Comprehensive Training/Safety program, in the Air Force, and HARDMAN, or Hardware vs. Manpower program, in the Navy).

Congress, recognizing the importance of MPTS in materiel acquisition, requires that all services provide a manpower estimate report (MER) before a major system may proceed to full-scale development. The MER provides a quantitative analysis of the manpower, personnel, and training burden. Increased awareness of MPTS has caused the defense acquisition community to realize that designing equipment correctly the first time is less costly than trying to correct an error after production.

MANPRINT played a major role in the development of the engine for the Light Helicopter Experimental (LHX) program. The two companies competing for the contract approached the MANPRINT challenge in different ways. One solicited comments from 600 Army mechanics. The other gave a high-school industrial arts class the opportunity to perform maintenance on the engine. Both these exercises yielded valuable operator-in-the-loop feedback and resulted in the selection of an engine that requires only six tools for unit-level maintenance as compared to 134 for the previous engine.

Another program that was significantly improved by the implementation of MANPRINT is the Howitzer Improvement Program (HIP). Successful MANPRINT application resulted in:

- personnel savings—crew size was reduced from five soldiers to four;
- decreased maintenance time—mean time to repair was decreased from 4.1 hours to 1 hour;
- monetary savings—total life-cycle cost savings were in excess of $6 million.

These facts clearly illustrate the ad-

MANPRINT, on page 6

MANPRINT, from page 5

vantages of MANPRINT when successfully implemented.

The MANPRINT program can also have a widespread impact on non-Army activities. The federal government, the taxpayer, and private industry all reap the profits. Reduced acquisition costs, safer and more efficient equipment for today's soldier, and a private sector that can produce an item in the most cost-effective manner are all by-products of the MANPRINT program.

The basic tenets of the MANPRINT philosophy can be applied by private industry to nondefense business as well. Such an application will increase efficiency and customer satisfaction. When an item of equipment does not require extensive follow-up after receipt, the purchaser is more likely to return to the supplier with repeat business.

MANPRINT training courses are available for both government and industry personnel. There is no charge for companies executing an Army contract. The MANPRINT Staff Officer's course is three weeks in length and is oriented toward MANPRINT practitioners. This course provides detailed, hands-on instruction and is conducted at Fort Belvoir, VA.

The MANPRINT Senior Training Course is designed for general officers, executives, and managers. This one-week course provides an overview of MANPRINT policies and procedures and is conducted at different government sites throughout the country.

Additional information on these courses may be obtained from Mr. Warren Ashley, Soldier Support Center—National Capital Region, at (703) 325-3706 or Autovon 221-3706.

MANPRINT with Industry seminars are conducted semiannually and provide an excellent forum to gain insight into MANPRINT philosophy and practice. Industry representatives have the opportunity to share ideas on how to improve the program and to indicate what they feel the problems are.

One result of such dialogue was the publication of Army Acquisition Executive Memorandum 89-2, Treatment of MANPRINT in Solicitations and the Source Selection Process. Industry indicated that the establishment of MANPRINT as a separate major area in source selection had not received adequate emphasis by the Department of the Army. As a result, General Arthur E. Brown, Jr., then Vice Chief of Staff of the Army, directed that an Army Acquisition Executive Memorandum be written to establish MANPRINT as a separate major area with the same visibility as the technical, management, and cost areas. This action was a significant step toward the successful institutionalization of MANPRINT.

Information on the seminars and MANPRINT in general can be obtained from the Department of the Army point of contact, LTC Rudolph Laine, HQDA, Attn: DAPE-MR, Washington, DC 20310-0300; (202) 695-9213, Autovon 225-9213.

In today's environment, human and fiscal resources are in short supply. As a result, commercial companies and government agencies must accomplish more with fewer resources. The MANPRINT program has enabled the Army to increase its warfighting capability in a resource-efficient and effective manner. Successful implementation of MANPRINT also guarantees that technology is used not to exclude the individual but to enhance the individual's operation of the system. ●

Barbara K. Frank is Management Analyst at the MANPRINT Directorate, Office of the Deputy Chief of Staff for Personnel, Department of the Army.

ENGINEERING DATA COMPENDIUM
Human Perception and Performance

"A landmark human engineering reference for system design"

The **Engineering Data Compendium: Human Perception and Performance** (edited by Kenneth R. Boff and Janet E. Lincoln) is available through CSERIAC.

The **Compendium** is a standardized professional reference tool that consolidates human sensory/perceptual and performance data in a form useful to system designers.

The **Compendium** provides useful and reliable information from 76 research areas dealing with performance capabilities and limitations of the human operator.

Over 1100 individual entries incorporate basic human performance data, summary tables integrating data from related studies, models and quantitative laws, and interpretive background information on selected topics.

Entries are supplemented by nearly 2000 figures, tables, and illustrations.

Cost of the three-volume set with *User's Guide* is $295. For further information, contact the CSERIAC Program Office.

PRODUCTS and SERVICES

CSERIAC provides a variety of products and services to accomplish its core mission to support the requirements of the Department of Defense for incorporating crew system ergonomics in the design and operation of military systems. The following is a list of the products and services currently available from CSERIAC:

MODELS AND SOFTWARE

Articulated Total Body (ATB) Model: This 3-D model predictively simulates the gross motion dynamics of the human body. Primary applications are to ejection and survivable aircraft and road vehicle crash problems. A Generator of Body Data (GEBOD) program is also available which provides different size child, female and male, as well as Hybrid II and Hybrid III dummy data sets for the ATB model. Unclassified/Limited Distribution (Qualified Users Only). Cost $1000.00.

COMputerized Biomechanical MAN-Model COMBIMAN: A 3-D interactive computer-graphics model, used to evaluate the physical accommodation of a pilot to existing or conceptual crewstation designs. Performs four types of analyses: fit, visibility, reach, and strength for operating controls with the arms and legs. Body size and proportions of the man-model are configurable, using a 35-segment link system that functionally corresponds to the human skeletal system. Unclassified/Unlimited Distribution. Cost $200.00.

CREW CHIEF:
model of an aircraft maintenance technician used to perform human factors evaluations of aircraft maintenance crewstations. CREW CHIEF is an expert system that allows the designer to simulate a maintenance activity using computer generated imagery and determine whether required activities are feasible for a given crewstation configuration. CSERIAC can provide in-house analysis (cost varies) for those who do not have operating systems that support CAD. Unclassified/Unlimited Distribution. Cost $200.00 (excluding system independent version).

Criterion Task Set - CTS: A battery of tests designed to place selective demands on the mental resources and information processing functions of the human operator. Designed for application to a variety of human performance research areas including workload metric evaluation, assessment of stress effects, and human performance evaluations. Includes nine standardized tasks that tap perceptual, central processing, and response output resources. Unclassified/Unlimited Distribution. Cost $50.00.

Head-Spine Model: A predictive simulation program for human spine response to abrupt accelerations and impacts applied to the torso. A totally 3-D model based on structural mechanics principles and the finite element analysis method, which provides predictions of stresses at up to 24 vertebral levels. Unclassified/Limited Distribution (Qualified Users Only). (Available Spring 1990)

HyperText Stack for MIL-STD 1472D (BETA test version): Enables quick location and extraction of specific items of information from MIL-STD 1472 ("Human Engineering Criteria for Military Systems, Equipment and Facilities"). Based on the content of a pre-release version of the "D" revision of MIL-STD 1472. Unclassified/Limited Distribution (U.S. Government organizations Only). Cost $75.00.

Optical Signature, Acquisition and Detection System - OSADS: A model that calculates air vehicle detectability for man-in-the-loop electro-optical or visual sensor systems. Computes the optical signature of the target under dynamic conditions and does not require the input of estimates. The model depicts a dynamic engagement between an air-vehicle and a ground-based threat sensor by simulating lighting conditions and calculating the optical characteristics of the target. Unclassified/Limited Distribution (DoD agencies only). Cost $100.00.

Psychophysiological Assessment Test System - PATS: The PATS is a comprehensive microcomputer test system used for the measurement of psychophysiological data. It was designed to address multifunctionality in terms of testing environments and research applications, financial econ-

omy, and usability. Its capabilities include data reduction and management, statistical analysis, and interface with simulator facilities. Unclassified/Unlimited Distribution. (Available Spring 1990)

Subjective Workload Assessment Technique - SWAT: An easily administered subjective scaling method to be used in the cockpit or other crewstations to quantify the workload associated with various activities. Postulates a multidimensional model of workload comprising three, three-point dimensions or factors: (1) time load, (2) mental effort load, and (3) psychological stress load. User's Guide and Scale Development software. Unclassified/Unlimited Distribution. Cost $50.00.

User Assisted Test and Evaluation Methodology Assistant Program: Version I-TEMAP: A software tool that cross-references critical test and evaluation issues with potential problem-solving methods, techniques, procedures, and guidelines. Intended to organize the systems experimentation protocols, serve as a guideline (checklist) of considerations that must be given to system experimentation projects, and stimulate additional methodological research to improve test and evaluation procedures. Unclassified/Unlimited Distribution. Cost $75.00.

The User-Assisted Automated Experimental (Test) Design Program - AED: An interactive computer program that enables use of a variety of test designs for test and evaluation programs. AED presents a detailed test design defining the factors and levels tor each test run. Current capability of AED includes full and fractional factorial designs, central composite designs, the definition of aliased terms in the design Unclassified/Unlimited Distribution. Cost $75.00.

PUBLICATIONS

CSERIAC Gateway: A quarterly current awareness newsletter published by CSERIAC. It serves as a source of current human factors information for the CSE community. Unclassified/Unlimited Distribution. Free of charge.

Engineering Data Compendium (K. Boff, J. Lincoln, Eds.): A reference tool which consolidates human sensory/perceptual and performance data. Consists of brief, encyclopedia-type entries in a format designed for ease of understanding, interpretation, and application in the presentation of technical information. Consists of four volumes (2758 pages),1100 entries, and nearly 2000 figures, tables, and illustrations. Unclassified/Unlimited Distribution. Cost $295.00.

Applications of Human Performance Models to System Design (G. McMillan, D. Beevis, E. Salas, M. Straub, R. Sutton, L. Van Breda, Eds.): The proceedings of a NATO/AGARD conference on Applications of Human Performance Models to System Design, held in Orlando, Florida, May 9-13, 1988. Focus on the application of human performance prediction tools in workspace design, task allocation, and workload analysis. Topics also include models of individual tasks, multi-task situations, and crew performance. Unclassified/Unlimited Distribution. Cost $60.00.

Three-Dimensional Displays: Perception, Implementation, and Applications (C. Wickens, S. Todd, and K. Seidler): A state-of-the-art report on 3-D display technology. Perceptual cues used to perceive depth are described and data bearing on the interaction among these cues are discussed. Techniques for implementing perspective and stereoptic displays and 3-D display technology applications in the following areas are described: flight deck displays, air traffic control, meterology, teleoperation, and computer graphics. Unclassified/Unlimited Distribution. Cost $75.00.

DATABASES

AAMRL Biodynamics Data Bank: A repository for data from impact acceleration biodynamics experiments. It can fully index and provide extensive descriptive and summary data for large-scale biodynamics experiments. Bibliographic records include literature pertaining to biomechanics and related physiology as well as reports emanating from research conducted at AAMRL and other laboratories. Unclassified/Unlimited Distribution. Cost varies as a function of time on-line. Minimum Cost $100.00.

Center for Anthropometric Research Data (CARD) Anthropometric Data Base: An on-line database developed to support human engineering design activities. It contains several hundred measurements of the human body across large population samples from numerous published anthropometric surveys. Available data include measurement frequency data and summary statistics, measurement descriptions, and measurement classification by body region and measurement type. Unclassified/Unlimited Distribution. Cost $50.00.

SERVICES

Technical and Bibliographic Inquiries: Customized responses to technical and bibliographic inquiries from engineers and designers related to the ergonomics of crew system design. Each request receives the personal attention of expert technical and bibliographic information analysts who compile requested information and communicate the results to the user. Cost varies.

Workshops, Conferences, Symposia, Short Courses: CSERIAC can sponsor and organize workshops, conferences, symposia, and short courses to apprise scientists and engineers of important developments in crew system ergonomics and to provide opportunities for professional development. Cost varies.

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CHIEF SCIENTIST'S REPORT

Donald J. Polzella

Much of the day-to-day activity of the CSERIAC technical staff is concerned with responding to user requests for bibliographic and technical information related to crew system design. (We have responded to over 100 inquiries to date!) Depending on the information requested, CSERIAC analysts may search appropriate bibliographic databases, consult handbooks or other reference sources in its core library, or contact leading technical experts in its network who can help locate the desired information.

The following case studies illustrate how CSERIAC goes about responding to user requests. The cases described reflect both the range of inquiries we receive and the different ways these inquiries may be handled.

One of the first inquiries was from an applied experimental psychologist at the US Naval Air Development Center, who was looking for ways to attenuate vibration-induced seat discomfort. The seat causing the problem was located in an aircraft that flew long missions under turbulent conditions. A simple solution was not possible, since the source of the discomfort, the seat, couldn't be adjusted.

We provided the psychologist with some useful general information on the topic from Boff and Lincoln's *Engineering Data Compendium*. This included the vibration characteristics of fixed-wing and rotary-wing aircraft and equations for predicting the transmission of vibration through seats and the effectiveness of seats in isolating the human body from vibration.

We also supplied him with an annotated bibliographic report containing over 150 abstracts compiled from the Defense Technical Information Center (DTIC), NASA, and COMPENDEX (Engineering Index) databases, which dealt with the vibration-attenuating effectiveness of various cushioning materials.

Another inquiry came from a senior officer at the Air Force Inspection and Safety Center at Norton AFB, who needed to know how quickly a person could press a foot pedal in response to a visual signal. Expert network members Dick Pew (BBN Laboratories, Inc.), Andy Rose (American Institutes for Research), and Chris Wickens (University of Illinois) provided data and the names of researchers active in this area, and pointed us to two particularly germane articles in the journal *Human Factors*. We were able to fax the appreciative officer copies of the articles a few hours after receiving his inquiry. (By the way, it takes about one and one-third seconds to press a foot pedal in response to a visual signal.)

Boff and Lincoln's *Engineering Data Compendium,* one of our primary reference tools, has, on several occasions, provided data and information that precisely matched a user's request.

An engineer involved in the design of alternate display devices asked CSERIAC whether we could obtain any information on the relationship between CRT raster scan characteristics and alphanumeric character legibility. We sent him a copy of a Compendium entry that contains data showing letter-identification accuracy as a function of scan line orientation at two levels of display resolution and two exposure durations.

Another engineer was involved in upgrading a wind tunnel control console. Thumb wheels are currently employed as the primary user interface, but alternative input devices needed to be explored for the upgrade. The engineer asked whether there are any performance data that compare various input devices. We were able to provide him with Compendium entries giving speed and accuracy data as well as recommended configurations for a variety of hand-activated controls, including thumb wheels, rotary selectors, pushbuttons, assorted keyboards and keysets, and levers.

One unusual request came from a designer at a major automobile manufacturing company, who asked whether CSERIAC could provide data on finger/hand injuries that might be applicable to the design of "autoexpress" closure systems for windows and sun roofs. He had already contacted the National Institute of Occupational Safety and Health (NIOSH), the Consumer Product Safety Commission, and several universities, but they were unable to provide relevant information.

We contacted the Injury Control Department at the Center for Disease Control, the Auto Safety Office of Technical Reference at the Department of Transportation, and the National Safety Council, but we were also unsuccessful in obtaining the desired information. However, our search of the DTIC and MEDLINE *(Index Medicus)* databases turned up some useful information on protective devices and the anatomical effects of various finger/hand injuries. We also provided the designer with some general guidelines from MIL-STD-1472D (*Human Engineering Design Criteria for Military Systems, Equipment and Facilities)*.

An Air Force civil servant needed to justify to her supervisor the purchase of a certain visual display terminal (VDT) workstation and asked if CSERIAC could provide information on recommended heights of VDT keyboard support surfaces. The workstation scheduled for purchase had a support surface height of 26 to 27 inches. She maintained that this would be too high, due to her chronic back problem.

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NATO AGARD Test Battery and Performance Database

Attempts to integrate findings from human performance studies are hindered by variations in testing methods. Perhaps because it is rooted in the experimental rather than the psychometric tradition, performance assessment is one area of psychological testing in which standardization is not a routine component of test construction. While there is a fair degree of consensus regarding the types of tasks that provide useful information in performance studies (e.g., tracking, memory scanning, verbal reasoning), differences in testing protocols are a source of confounding that may account for inconsistencies in the data.

In 1987 the Aerospace Medical Panel (AMP) of the NATO Advisory Group for Aerospace Research and Development (AGARD) formed Working Group 12 (WG 12) to address this problem. This group, comprising performance researchers from Europe and the United States, had three objectives: (1) to compile and publish an international register of performance research; (2) to develop a standardized psychometric test battery for assessing the effects of environmental stressors on human performance; and (3) to establish a central data bank for storing data collected using the battery.

The first objective was accomplished through the issuance of the *Performance Assessment Register* (AGARD Report No. 763), a compilation of over 350 European and North American performance researchers. The Register is designed to facilitate communication among active researchers and includes names, addresses, telephone numbers, and performance methodologies employed. The information is cross-indexed to human-performance-related key words.

The second objective was accomplished through the development of the AGARD Standardized Tests for Research with Environmental Stressors (STRES) Battery, a laboratory-based collection of seven common tests with a proven record of success in stress research. Included are tests of reaction time, mathematical processing, memory search, spatial processing, unstable tracking, grammatical reasoning, and a dual task combining tracking with concurrent memory search.

The AMP Working Group 12 and AGARD Lecture Series 163, *Human Performance Assessment Methods*

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State-of-the-Art Report

THREE-DIMENSIONAL DISPLAYS

Perception, Implementation, Applications

CSERIAC is proud to announce the publication of its first state-of-the-art report, **Three-Dimensional Displays: Perception, Implementation, and Application**, by Christopher D. Wickens, Steven Todd, and Karen Seidler.

The perceptual basis of three-dimensional (3D) representation, recent advances in 3D display implementation, and current 3D design applications are examined in this authoritative review of the state of the art in 3D display technology.

The report catalogues the basic perceptual cues that can be built into a display to convey a sense of "natural" 3D viewing or depth. It describes how the various cues interact and how cues can be combined appropriately to create the strongest sense of depth.

Techniques for implementing perspective and stereoscopic displays are described in detail.

The report identifies some potential costs and risks associated with 3D display technology, including the potential for perceptual ambiguity. Ways of constructing 3D displays to reduce ambiguities are suggested.

The efficacy of 3D vs. 2D representations is compared for various display contexts, and the most useful 3D application environments are noted.

The report reviews 3D display technology applications in several major areas: flight deck displays, air traffic control, meteorology, teleoperation and robotics, computer-aided design, and graphic data analysis and imaging.

Senior author of the report, Dr. Christopher Wickens, is head of the Aviation Research Laboratory, University of Illinois.

The report is 126 pages and includes 22 figures. Cost is $75.00. To order, contact the CSERIAC Program Office.

Defining Human Factors

At the request of the Human Factors Committee of the National Research Council, CSERIAC analyzed existing definitions of *human factors* to aid the committee in establishing a standardized definition of the field. Although there are many definitions of *human factors,* a formally endorsed, unified definition does not exist.

CSERIAC compiled and analyzed definitions of *human factors* and related terms from a range of key reference sources and presented its findings to the committee to expedite its deliberations. Searches for appropriate resource materials were conducted at four area libraries using computerized catalogues. Definitions were extracted from 74 references, yielding a final sample of 90 verbatim definitions.

Many of the definitions had three components: the category (genus) of classification (e.g., field, discipline, profession, etc.); the domains of inclusion (e.g., biology, behavioral sciences, etc.); and the objectives (e.g., to increase system safety through application of human performance data in design). A standardized definition of *human factors* should probably incorporate all these components.

The definitions assembled for the analysis can be grouped into three general classes: *human factors, human factors engineering,* and *ergonomics*. The *human factors* definitions in our sample are characterized by a broader category of classification and broader objectives. The *human factors engineering* definitions overwhelmingly emphasize design as the medium for effecting change in end systems. Definitions of *ergonomics* stress the study of humans at work.

These differences among the terms *human factors, human factors engineering,* and *ergonomics* must be considered in developing a single, unifying definition of the field.

Our analysis reveals a chronological trend towards broadening both the domains of inclusion and the objectives of the human factors field. Originally, the focus of human factors was the design of military man-machine systems; this focus has expanded to include private industrial systems and consumer products as well. Thus, the field has moved from a discipline born in a postwar, militarily oriented engineering environment to one active in a more global manufacturing and consumer-oriented environment.

A summary report of the analysis of human factors definitions may be obtained from the CSERIAC Program Office.

HyperText Stack for MIL-STD-1472D

A Macintosh® HyperCard™ version of MIL-STD-1472D (*Human Engineering Design Criteria for Military Systems, Equipment and Facilities*) has been developed by the U.S. Army Human Engineering Laboratory. The HyperText Stack for MIL-STD-1472D (HT-1472) allows users to quickly locate and extract specific items of information from this widely used standard.

HT-1472 is based on a pre-release version of the "D" revision of MIL-STD-1472. HT-1472 is a BETA test version and will run on any Apple Macintosh® with HyperCard™ 1.2 or higher (2M RAM recommended). CSERIAC can provide U.S. Government organizations with the current version of HT-1472 for a cost-recovery price of $75.00 (includes 2 diskettes and manual). Nongovernment organizations should refer their requests to:

Carlow Associates, Inc.
8315 Lee Highway, Suite 410
Fairfax, VA 22031
(703) 698-6225

Recommended Reading

***How to Get It: A Guide to Defense-Related Information Resources.* By Gretchen A. Schlag (Compiler) and Charles E. Reed (Database Development). December 1988. Alexandria, VA, Defense Technical Information Center (DTIC). 626 pages. $42.00/ $55.95. AD-A201 600.**

Second update of DTIC's information resource directory, designed to help users identify and obtain government-published or government-sponsored technical documents, maps, patents, specifications, and standards. Lists information resources produced by or for the Department of Defense (DoD) as well as selected material from other sources, such as the National Technical Information Service (NTIS), NASA, and the Department of Energy.

Available to DoD components and DoD contractors from DTIC-BC, Cameron Station, Alexandria, VA 22304-6145, (202) 274-7633 ($42.00). Others must order from NTIS, 5285 Port Royal Road, Springfield, VA 22161, (703) 487-4600 ($55.95).

***Information Resources for Engineers and Scientists.* 5th edition. 1989. Washington, DC, INFO/tek. Approx. 600 pages. $95.00.**

A comprehensive handbook designed to assist engineers and scientists in researching technical topics by providing a working knowledge of major information resources, references, and online databases. Outlines strategies for locating a wide variety of information sources in any topical area, from abstracts, handbooks, and review literature to conference proceedings, patents, translations, and government documents.

Available from INFO/tek, 4318 Fessenden St., NW, Washington, DC 20016, (202) 263-9147.

Readers are invited to submit article proposals, comments, and suggestions to: CSERIAC Gateway Editor, AAMRL/HE/CSERIAC,Wright-Patterson Air Force Base, OH 45433-6573; (513) 255-4842, Autovon 785-4842.

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The American National Standard for Human Factors Engineering of Visual Display Terminal Workstations, published by the Human Factors Society, contained the information she needed. The standard states that an adjustable keyboard support should accommodate a range of 23 to 28 inches. For a nonadjustable keyboard support, the height should be such that the angle between the upper arm and the forearm is between 70 and 135 degrees.

A senior industrial engineer was planning to establish an "ergonomics department" at a midwestern foundries corporation and asked if CSERIAC could help by providing information on existing ergonomics/human factors specifications and standards for human-machine system design. We sent him an annotated list of over twenty standardization documents extracted from the Department of Defense Human Factors Standardization Document Program Plan. The engineer could obtain most of the documents from the National Standards Association in Washington, DC.

We also sent the engineer a course description and enrollment application for a highly recommended two-week course sequence on human factors engineering offered each summer by the University of Michigan College of Engineering. In addition, we forwarded a list of professional organizations, references, journals, and other resources related to human factors engineering. Finally, we were able to identify a particularly relevant report issued by the National Institute for Occupational Safety and Health, *An Evaluation of Occupational Health Hazard Control Technology for the Foundry Industry*.

One recent request came from an Air Force officer involved in the design of an active noise-reduction system for the B2 development program. (In an active noise-reduction system, unwanted noise is cancelled or attenuated through the addition of a system-induced electroacoustical signal.) The officer needed information on recommended noise exposure levels that could help support the design process. Since he was already familiar with Air Force standards and guidelines on recommended noise exposure levels, we provided him with relevant material from NASA, OSHA, and NIOSH documents, and from military standards related to Army and Navy crew systems. ●

CSERIAC Products and Services Subscription Plan

The University of Dayton is pleased to announce a convenient and flexible means for obtaining CSERIAC services. Customers who use our services on a regular basis can now establish a prepaid subscription account. A minimum deposit of $1000 is required to open a subscription account. A maximum of $300,000 can be placed in the account without specific contracting officer approval. Costs of services rendered and/or products purchased will be subtracted from the balance. Subscribers may charge against funds placed in the account for up to two years, and additional funds can be added at any time.

Prepaid subscriptions can be established by organizations in the Department of Defense and other government agencies, as well as by U.S. Government contractors. Other domestic and international customers, including academic institutions and corporate users, may also establish prepaid accounts. (Products and services will be provided to these users to the extent practicable within DoD security guidelines and DoD policy regarding the handling of information on militarily critical technologies.)

Probably the greatest advantage to this accounting system will be time savings to customers. Requests for services and products can be carried out immediately without further review, avoiding the normal contractual time delays.

CALENDAR

March 4-9, 1990
"Human Interfaces for Teleoperators and Virtual Environments." Santa Barbara, CA, Sheraton Hotel and Spa. Sponsored by the Engineering Foundation. Contact Harold A. Comerer, Director, Engineering Foundation, 345 East 47th St., New York, NY 10017; (212) 705-7835, telex 126022.

April 1-5, 1990
CHI '90, Human Factors Computing Systems. Seattle, WA, Convention Center. Theme: "Empowering People." Sponsored by the Association for Computing Machinery's SIGCHI. Contact Toni MacHaffie, P.O. Box 5847, Beaverton, OR 97006-5847; (503) 591-1981, fax (503) 642-3934, CSNET: machaffie.chi@xerox.com.

April 2-6, 1990
The Ergonomics Society 1990, Annual Conference. Yorkshire, England, University of Leeds. Contact Bell Howe Conferences, ES Conference Secretariat, Gothic House, Barker Gate, Nottingham NGI 1JU, England; (0) 602-410679.

April 25-27, 1990
COIS 90-Conference on Office Information Systems. Cambridge, MA, Massachusetts Institute of Technology. Sponsored by ACM-SIGOIS and IEEE Computer Society TC-OA, in cooperation with IFIP 8.4. Contact Robert B. Allen, General Chair, 2A-367, Bellcore, 445 South St., Morristown, NJ 07960-1910; (201) 829-4315, email: rba@bellcore.com.

May 14-18, 1990
27th Annual Symposium, Seminar, and Exhibition of the Society for Information Display. Las Vegas, NV, Bally's Grand Hotel. Contact Lynne Henderson, Palisades Institute for Research Services, Inc., 201 Varick St., Room 1140, New York, NY 10014; (212) 620-3375, fax (212) 620-3379.

May 21-25, 1990
NAECON '90, National Aerospace and Electronics Conference. Dayton, OH, Convention Center. Sponsored by IEEE and cosponsored by HFS and others. Contact HFS Tech Society Liaison, Dr. Robert P. Bateman, 807 Morningview, Derby, KS 67037; or Dr. Dana Rogers, Papers Committee, 5842 Stonegate Court, Dayton, OH 45424.

May 23-25, 1990
5th Mid-Central Ergonomics/Human Factors Conference. Dayton, OH, University of Dayton. Contact Dave Biers, Department of Psychology, University of Dayton, Dayton, OH 45469; (513) 229-2161.

July 15-18, 1990
3rd International Conference on Industrial and Engineering Applications of Artificial Intelligence and Expert Systems. Charleston, SC. Contact Dr. Manton M. Matthews, Department of Computer Science, University of South Carolina Institute, Columbia, SC 29208; (803) 777-3285.

August 12-16, 1990
2nd International Conference on Human Aspects of Advanced Manufacturing and Hybrid Automation. Honolulu, HI, Hilton Hawaiian Village. Sponsored by the University of Louisville and the International Ergonomics Association. Contact Mansour Rahimi, Program Chair, Institute of Safety and Systems Management, University of Southern California, Los Angeles, CA 90089-0021; (213) 743-8972, fax (213) 747-7182.

September 26-29, 1990
23rd Annual Conference of the Human Factors Association of Canada. Ottawa, Canada, Skyline Hotel. Theme: "A View to the Future." Contact Human Factors Association of Canada/Association Canadienne d'Ergonomie, 6519B Mississauga Road, Mississauga, Ontario L5N 1A6, Canada; (416) 567-7193, fax (416) 567-7191.

Notices for the calendar should be sent to CSERIAC Gateway Calendar, CSERIAC Program Office, AAMRL/HE/CSERIAC, Wright-Patterson AFB, OH 45433-6573, at least five months in advance.

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(AGARDograph No. 308) contains detailed technical and data specifications, training requirements, and instructions to subjects for each of the seven tests. The specifications are hardware independent, thereby permitting the tests to be implemented on a variety of systems. For example, WG 12 has demonstrated the battery using Walter Schneider's Micro Experimental Laboratory (MEL) high-level task development software.

CSERIAC was asked by WG 12 to support the third objective, establishment of a central repository for the storage and retrieval of unclassified data collected using the STRES Battery. Due to the widely distributed network of performance researchers, two centers will coordinate and manage the STRES Battery Database. The European coordinator will be Anthropologie Appliquée, located at l'Université René Descartes in Paris.

European users of the battery are asked to transmit their data to Anthropologie Appliquée. CSERIAC, as the North American coordinator, will receive data from U.S. and Canadian users. (The data exchange format is already specified in AGARDograph No. 308.)

Formal procedures will be developed for the exchange of unclassified data between Anthropologie Appliquée and CSERIAC, so that each organization can provide its users with data from the widest possible range of sources.

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CSERIAC Products and Services

CSERIAC's objective is to acquire, analyze, and disseminate timely information on crew system ergonomics (CSE). The domain of CSE includes scientific and technical knowledge and data concerning human characteristics, abilities, limitations, physiological needs, performance, body dimensions, biomechanical dynamics, strength, and tolerances. It also encompasses engineering and design data concerning equipment intended to be used, operated, or controlled by crew members.

CSERIAC's principal products and services include:

- technical advice and assistance;
- customized responses to bibliographic inquiries;
- written reports in the form of state-of-the-art reports and technology assessments;
- reference resources such as handbooks and data books.

Within its established scope, CSERIAC also:

- organizes and conducts workshops, symposia, and short courses;
- manages the transfer of technological products between developers and users;
- performs special studies or tasks for government agencies.

Services are provided on a cost-recovery basis. An initial inquiry to determine available data can be accommodated at no charge. Special tasks require approval by the Program Manager.

To obtain further information or request services, contact:

CSERIAC Program Office
AAMRL/HE/CSERIAC
Wright-Patterson AFB, OH 45433-6573

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CSERIAC Gateway is published quarterly and distributed free of charge by the Crew System Ergonomics Information Analysis Center (CSERIAC). *Editor,* Janet Lincoln; *Associate Editor,* Deborah Licht; *Editorial Staff,* Anita Cochran, Cindy Day